

REMARKS

Claims 1-9, 14-15, 17, 18 and 20-21 are pending in this application. By the Office Action, claims 1-9 and 20 are withdrawn from consideration, and claims 14-15 and 17-18 are rejected under 35 U.S.C. §103. By this Amendment, claims 14 and 15 are amended and new claim 21 is added. Support for the amendments can be found throughout the entire specification, for example at paragraph [0025] and Example 3. No new matter is added by this Amendment.

Applicants appreciate the courtesies shown to Applicants' representative by Examiner Hoffmann in the March 15, 2007, personal interview. Applicants' separate record of the substance of the interview is incorporated into the following remarks.

I. Rejections Under 35 U.S.C. §103(a)

A. JP 479 in view of Schonfelder

Claims 14, 15, 17 and 18 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over JP 01-188479 ("JP 479") in view of U.S. Patent No. 5,746,969 ("Schonfelder") and U.S. Patent No. 5,298,470 ("Chia"). This rejection is respectfully traversed.

The Patent Office alleges that JP 479 teaches all of the features recited in the present claims except for the use of oxides. The Patent Office introduces Schonfelder as allegedly teaching that a mixture of yttria and alumina is a particularly advantageous sintering aid, and cites Chia as disclosing that a 1:1 ratio of yttria and alumina is known. The Patent Office thus alleges that it would have been obvious to use both oxides in the claimed ratio to aid the sintering of JP 479 because it is allegedly advantageous to do so. Applicants respectfully disagree with the Patent Office's assertions.

Independent claim 14 is directed to a method for making a microporous ceramic material having an average micropore size in the range from 0.8 μm to 1.2 μm and a porosity

in the range from 35 vol% to 40 vol% used as a substrate of a ceramic membrane used for gas separation, the method comprising: preparing a composition consisting essentially of a metal silicon powder, a silicon nitride powder, and both a yttrium oxide powder and an aluminum oxide powder as oxide powders such that a molar ratio of the yttrium oxide to the aluminum oxide is in a range of from about 0.8 to 1.2, wherein a mixing ratio of the metal silicon powder and the silicon nitride powder is 10 parts or more, but less than 100 parts, of the metal silicon powder with respect to 100 parts of a total amount of the silicon nitride powder in a mass ratio, and the content of the oxide powders is an amount corresponding to 2 mass% or more, but less than 250 mass%, of the content of the metal silicon powder, and not more than 20 mass% of the total amount of the metal silicon powder, the silicon nitride powder and the oxide powders, and an average particle size of each of the metal silicon powder and the silicon nitride powder contained in the composition is in a range from 1 μm to 50 μm , molding the composition into a molded product, and subjecting the molded product to reaction sintering in an atmosphere that allows nitriding and in a temperature range from 1200°C to 1500°C for two hours or more, but less than 12 hours. The claim further specifies that the reaction sintering is performed by heating the molded product in the atmosphere from room temperature to 700°C or more, but less than 900°C at a temperature increase rate of 2°C/min or more, but less than 10°C/min; further heating the product in the atmosphere to 1200°C or more, but less than 1500°C at a temperature increase rate of 1°C/min or more, but less than 5°C/min; and thereafter storing the sintered product in the atmosphere in said temperature range. Such a method is not taught or suggested by the cited references.

The requirements for a prima facie case of obviousness are specified and described in MPEP §2143. According to MPEP §2143, to establish a prima facie case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation to modify the references. Second, there must be a reasonable expectation of success. Third, the prior art

reference must teach or suggest all the claim limitations. The references applied in the Office Action fail to teach or suggest all the claim limitations, and fail to provide the required motivation to modify and combine the disclosures of the references.

1. The References Do Not Teach or Suggest
the Claimed Reaction Sintering Process

Claim 14 specifies that the reaction sintering is performed by heating the molded product in the atmosphere from room temperature to 700°C or more, but less than 900°C at a temperature increase rate of 2°C/min or more, but less than 10°C/min; further heating the product in the atmosphere to 1200°C or more, but less than 1500°C at a temperature increase rate of 1°C/min or more, but less than 5°C/min; and thereafter storing the sintered product in the atmosphere in said temperature range. This reaction sintering is nowhere taught or suggested by the cited references.

JP 479 discloses a process for producing a silicon nitride sintered body using a nitriding treatment. See translation of JP 479 at Claims. However, JP 479 nowhere appears to disclose any specific conditions, temperatures, or the like relating to the sintering conditions. In fact, Applicants submit that one of ordinary skill in the art, based on a thorough reading of JP 479, would not be able to precisely determine the specific sintering conditions used in JP 479. JP 479 is completely silent with respect to sintering process steps, temperatures, temperature rise, and the like, and thus provides no specific or even general guidance as to sintering the silicon nitride body. JP 479 thus entirely fails to have rendered obvious the reaction sintering steps of the claimed invention.

Schonfelder discloses a process for producing a dense silicon nitride material. See Schonfelder at Abstract. While Schonfelder discloses specific sintering conditions, those conditions include a sintering temperature of 1000-1450°C, under normal nitrogen pressure, in a reaction time of less than 30 hours. See col. 3, lines 42-49. More specifically,

Schonfelder teaches that the sintering process includes first heating the silicon nitride body in vacuum for 3.5 hours up to 800°C, followed by nitriding in a nitrogen atmosphere by heating for 1.5 hours up to 1170°C, heating for 4 hours up to 1370°C, a 1 hour pause, heating for 2 hours up to 1450°C, and a 10 hour pause. Col. 5, lines 49-51

Any combination of Kato and Schonfelder does not teach or suggest the claimed reaction sintering steps of heating the molded product in the atmosphere from room temperature to 700°C or more, but less than 900°C at a temperature increase rate of 2°C/min or more, but less than 10°C/min; further heating the product in the atmosphere to 1200°C or more, but less than 1500°C at a temperature increase rate of 1°C/min or more, but less than 5°C/min; and thereafter storing the sintered product in the atmosphere in said temperature range, as claimed. In particular, while claim 14 requires that the molded product is heated in the atmosphere from room temperature to from 700°C to 900°C, Schonfelder requires that the silicon nitride material is heated up to 800°C in vacuum, before nitrogen is introduced. Thus, the initial heating in Schonfelder does not allow nitriding to occur. See col. 5, lines 49-50, and col. 6, lines 25-26 and 55-56. Further, claim 14 specifies that the total reaction sintering is conducted in an atmosphere that allows nitriding and in a temperature range from 1200°C to 1500°C for two hours or more, but less than 12 hours. In contrast, Schonfelder teaches that the silicon nitride material is reaction sintered at temperatures of 1000°C or more for more than 18 hours in total. See col. 5, lines 49-59, col. 6, lines 25-35 and 55-58.

Nowhere does JP 479 or Schonfelder teach or suggest that any specific conditions should be used in JP 479, much less the specific conditions of Schonfelder. Furthermore, even if one of ordinary skill in the art would have been motivated to use Schonfelder's sintering conditions in JP 479, those conditions are significantly different from the reaction sintering conditions of claim 14. Nowhere does either JP 479 or Schonfelder teach or suggest

that Schonfelder's very specific conditions could or should be changed so as to practice the claimed invention, where such changes would still be expected to provide the desired results.

Incidentally, Chia does not overcome these deficiencies, but in fact arguable exacerbates the distinctions between the cited references and claim 14. Chia is directed to a sintered silicon carbide (not silicon nitride) body, and method of making such a body. However, Chia teaches that sintering is conducted at a temperature of 1775-2200°C or preferably 1900-2050°C. See col. 11, lines 12-14. However, these sintering temperature ranges are for sintering silicon carbide, not silicon nitride, and are far above the claimed sintering temperature 1200°C to 1500°C. If anything, any combination of Chia with JP 479 and Schonfelder would lead to sintering conducted at temperatures far above the claimed range.

These differences between the claimed invention and the cited references, particularly Schonfelder, are significant, because they produce significantly different results. These distinctions are described, for example, in paragraph [0025] of the present specification. In summary, if reaction sintering is performed under such high temperatures as are used in Schonfelder and Chia for a long time as in Schonfelder, fiber-like β -silicon nitride is produced, and thus densifies the silicon nitride product. In fact, this densification is specifically desired in Schonfelder, but is contrary to the claimed invention, which specifies a microporous ceramic material having an average micropore size in the range from 0.8 μm to 1.2 μm and a porosity in the range from 35 vol% to 40 vol%. Schonfelder thus teaches away from the claimed invention, by teaching methods that are specifically designed to densify the silicon nitride body, and does not teach or suggest modifying the specific sintering parameters to practice the claimed invention by making a microporous ceramic material as claimed.

For at least this reason, any combination of JP 479, Schonfelder, and Chia would not have rendered obvious the claimed invention. Schonfelder and Chia do not teach or suggest specific sintering steps, as claimed, for use in JP 479.

2. Chia is Improperly Combined with Schonfelder

Claim 14 specifies that both a yttrium oxide powder and an aluminum oxide powder as oxide powders are used as sintering aids, where the molar ratio of the yttrium oxide to the aluminum oxide is in a range of from about 0.8 to 1.2. The Office Action argues that this limitation would have been obvious from Schonfelder, which teaches the use of mixtures of yttria and alumina is particularly advantageous, and Chia, which allegedly teaches that a 1:1 ratio of yttria and alumina is known to be very stable. However, Schonfelder and Chia are directed to different materials, and thus are improperly combined.

Applicants acknowledge that Schonfelder teaches the use of mixtures of yttria and alumina as sintering aids. However, Schonfelder teaches their use in ratios well outside the claimed range of yttrium oxide to the aluminum oxide in a range of from about 0.8 to 1.2. For example, in the Examples of Schonfelder, the reference teaches the use of 11.2 wt% yttrium oxide and 2.8 wt% aluminum oxide. Converting these relative weight percent values to molar ratio yields a molar ratio of yttrium oxide to aluminum oxide of 1.8. This value is well outside the maximum claimed ratio value of 1.2 of claim 14. Nowhere does Schonfelder teach or suggest that its exemplified yttria:alumina ratio of 1.8 should be adjusted, specifically to be within the claimed range of 0.8 to 1.2.

Chia does not overcome this deficiency. The Office Action argues that Chia describes that a 1:1 ratio of yttria and alumina is known to be very stable. Applicants disagree, because Chia is in fact directed to different sintering materials. While Chia describes that molar ratios of 1:1, 1:2, and 3:5 are stable, those ratios refer to molar ratios of yttrium to aluminum in the final reaction product, not yttrium oxide (yttria) to aluminum oxide (alumina) as sintering

aids. See col. 6, lines 60-68. Furthermore, Chia does not even teach the use of aluminum oxide. Instead, Chia teaches that the sintering aid to provide the aluminum in the final product is aluminum nitride. See col. 5, line 59.

Thus, Chia's teachings of yttrium:aluminum ratios are incompatible with Schonfelder's sintering aid disclosure, and the references are improperly combined. One of ordinary skill in the art looking at Chia's ratio, derived from the use of aluminum nitride, would not have been motivated to select Schonfelder's yttria to alumina sintering aid ratio, and then to reduce that ratio from the disclosed 1.8 to the claimed range of 0.8 to 1.2.

For at least this additional reason, any combination of the cited references would not have rendered obvious the claimed invention, because the references in any proper combination do not teach or suggest the claimed ratio range for the sintering aids.

Chia as also not properly combined with JP 479 and Schonfelder, at least because Chia is directed to the production of different materials. That is, while JP 479 and Schonfelder are directed to forming sintered silicon nitride bodies, Chia is directed to forming sintered silicon carbide bodies. See Chia at Abstract. Nothing in the cited references teaches or suggests that any of the teachings of Chia, relevant to providing sintered silicon carbide bodies, could or should be used in the processes of JP 479 and/or Schonfelder for the production of sintered silicon nitride bodies. Thus, for this additional reason, the references are improperly combined, and one of ordinary skill in the art would not have looked to Chia to modify the processes of JP 479 or Schonfelder.

3. Conclusion

For at least these reasons, any combination of JP 479, Schonfelder, and Chia would not have rendered obvious the claimed invention. Reconsideration and withdrawal of the rejection are thus respectfully requested.

B. JP 479, Schonfelder, Chia, and Kingery

Claim 17 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over JP 479, Schonfelder, and Chia, and further in view of Kingery et al., "Introduction to Ceramics," second edition ("Kingery"). This rejection is respectfully traversed.

The Patent Office alleges that Kingery teaches that particle size is one of the most critical factors in ceramics processing. The Patent Office thus alleges that it would have been obvious to perform routine experimentation to determine the optimal particle size for the yttria.

Applicants submit that Kingery does not remedy the deficiencies of JP '479, Schonfelder, and Chia, discussed in detail above. Regardless of its actual disclosures, Kingery also does not teach or suggest the claim limitations that are missing from the primary references, and does not teach or suggest combining and thereafter modifying JP '479, Schonfelder, and Chia to practice the claimed invention.

For the foregoing reasons, Applicants submit that JP 479, Schonfelder, Chia, and Kingery, in combination or alone, do not teach or suggest all of the features recited in claim 17. Reconsideration and withdrawal of the rejection are thus respectfully requested.

II. Rejoinder

Applicants submit that upon allowance of elected claims 14, 15, 17 and 18, withdrawn claims 1-9 and 20 should be rejoined and similarly allowed.

III. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of the application are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,



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Attachment:
Petition for Extension of Time

Date: April 3, 2007

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